Lunar EVA Dosimetry: Microdosimeter-Dosimeter Instrument

Completed Technology Project (2009 - 2011)

Project Introduction

The overall objective of this research project is to design, develop, and test an engineering model solid-state microdosimeter (SSMD) by December 2012 suitable for use in the new NASA spacesuit and robotic operation on rovers, tool boxes, and spacecraft. The benchtop instrument continues to be used to develop and investigate improvements to the state-of-the-art of SSMDs. This past year the focus has been on development of improved preamplifiers. Radiation sources available at the USNA have been used to carry out the test protocols. The benchtop system has been expanded to obtain and analyze microdosimetric spectra for incident NSRL beams of both protons and heavy ions with identification of particle types in the beam, their energies, and their mass-to-charge ratios and those produced by intervening materials. We carried out tests of our bench-top system with a neutron beam generated in the Nucleonics Laboratory at the USNA with favorable results. An improved version of the flight engineering model, MIDN-III, has been designed and is nearing completion. It has a reduced footprint and mass and expanded remote command capability. It will be available for test by the end of 2010. We processed data sets obtained at the NSRL/BNL from our benchtop system, flight engineering model MIDN-II, and two Far West HAWK tissue equivalent proportional counters. Inter-comparisons of the observations agreed well and also agreed with Geant4 simulations. These spectra have been added to our past data sets to update our extensive library of microdosimetric spectra. We continued development our unique optical calibration system for a SSMD that permits continual end-to-end system test and calibration while the instrument is operational deployed. This is an alternative to using a radiation source that is problematic in a personal dosimeter and eliminates handling and shipping restrictions and personnel and facility certifications required by international, federal, and local regulations. Our provisional patent application was superseded by a patent application in Sep 2010. We have tested our second generation microdosimeter sensors with our bench-top and flight engineering instruments and compared our results favorably with those obtained at the University of Wollongong. We received a sample of our third generation solid-state microdosimeter sensors in November and will begin testing at the beginning of the year. We completed an initial conceptual design of our instrument to fit within a NanoRacks configuration for deployment on the International Space Station through the auspices of the DoD Space Test Program. The NanoRacks configuration is modeled after the design of a cubesat. Our configuration would be 10cm x 10cm x 15cm with the majority of the volume dedicated to a rechargeable battery power supply. [Ed. note 2/29/2012: PI Vincent Pisacane retired and end date changed to 9/30/2011; James Ziegler is new PI effective 10/1/2011 and project continues through 3/31/2013, per NSBRI. See Ziegler for FY2012 and later reports]

Anticipated Benefits

To determine the risk from currently used radiation dosimeters requires

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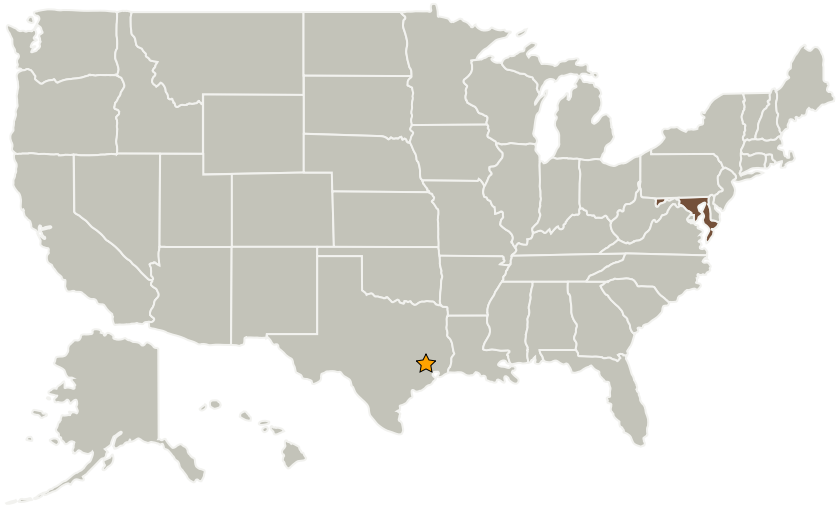
knowledge of the species, energies, and frequencies of the radiation types or the frequency distributions as a function of linear energy transfer. The more frequently used passive dosimeters are also processed after the exposure and are not real-time instruments so the risk is inferred only after exposure. Microdosimeters are unique in that they can be used to directly determine the regulatory risk from radiation in real time when neither the species nor energies of the radiation are known. Thus it is a superior instrument for use in situations when the radiation environment is unknown and perhaps time varying. With sufficient investment in very-large-scale integration (VLSI) technology the solid-state microdosimeter can be integrated into a portable instrument. Since microdosimetry provides the regulatory risks from radiation exposure in real time, it can be beneficially used by first responders in emergency situations when there is uncertainty in the radiation risk. The microdosimeter can be used in nuclear power plants and other facilities with radioactive materials to provide risk due to exposure. It can also be used to detect contraband radioactive material; because of its compact size and potentially relatively low cost, it can be used in situations where large numbers of sensitive detectors are needed. Development of Silicon on Insulator (SOI) microdosimeters has a potentialy significant impact on applications to monitor the dose equivalent during proton therapy to reduce the possibility of secondary cancers generated in normal tissue by the radiation. Development of our calibration technique that does not use an ionizing radiation source will reduce the exposure of handlers of the microdosimeter. It will also eliminate the the cost of satisfying the regulations on certification of users and on the handling, shipping, and facilities.

Primary U.S. Work Locations and Key Partners



Organizational Responsibility

Responsible Mission Directorate:

Space Operations Mission Directorate (SOMD)

Lead Center / Facility:

Johnson Space Center (JSC)

Responsible Program:

Human Spaceflight Capabilities

Project Management

Program Director:

David K Baumann

Principal Investigator:

Vincent L Pisacane

Co-Investigators:

Francis A Cucinotta
Quentin Dolecek
Marco Zaider
Anatoly Rozenfeld
Martin Nelson
John Dicello

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Organizations Performing Work	Role	Type	Location
★Johnson Space Center(JSC)	Lead Organization	NASA Center	Houston, Texas
Memorial Sloan-Kettering Cancer Institute	Supporting Organization	Industry	
United States Naval Academy	Supporting Organization	Academia	Chester, Maryland
University of Wollongong	Supporting Organization	Academia	

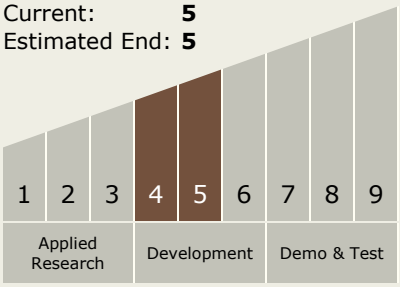
Primary U.S. Work Locations
Maryland

Project Transitions

January 2009: Project Start

Technology Maturity (TRL)

Start: **4**
Current: **5**
Estimated End: **5**



Technology Areas

Primary:

- TX06 Human Health, Life Support, and Habitation Systems
  - TX06.5 Radiation
    - TX06.5.5 Monitoring Technology

Target Destinations

The Moon, Mars

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September 2011: Closed out

Closeout Summary: NOTE: Former PI Vincent Pisacane retired as of 9/30/2011; James Ziegler is new PI effective 10/1/2011 and project continues, per NSBRI. See Pisacane for FY2011 and earlier reports (Ed., 2/29/2012) The overall objective of this research project is to design, develop, and test a prototype solid-state microdosimeter (SSMD) by September 2013, suitable for use in the new NASA spacesuit and robotic operation on rovers, tool boxes, and spacecraft. The benchtop instrument continues to be used to develop and investigate improvements to the state-of-the-art of SSMDs. This past year the focus has been on development of improved ultra-low noise preamplifiers and new sensors. Radiation sources available at the U. S. Naval Academy (USNA) have been used to carry out the test protocols. The benchtop system has been expanded to obtain and analyze microdosimetric spectra for incident NASA Space Radiation Laboratory (NSRL) beams of both protons and heavy ions with identification of particle types in the beam, their energies, and their mass-to-charge ratios and those produced by intervening materials. We carried out tests of our bench-top system with a neutron beam generated in the Nucleonics Laboratory at the USNA with favorable results. An improved version of the flight engineering model, MIDN-III, has been designed and is nearing completion. It has a reduced footprint and mass and expanded remote command capability. We processed data sets obtained at the NSRL/BNL from our benchtop system, flight engineering model MIDN-II, and two Far West HAWK tissue equivalent proportional counters. Inter-comparisons of the observations agreed well and also agreed with Stopping and Range of Ions in Matter (SRIM) and Geant4 simulations. These spectra have been added to our past data sets to update our extensive library of microdosimetric spectra. We continued development our unique optical calibration system for a SSMD that permits continual end-to-end system test and calibration while the instrument is operational deployed. This is an alternative to using a radiation source that is problematic in a personal dosimeter and eliminates handling and shipping restrictions and personnel and facility certifications required by international, federal, and local regulations. Our provisional patent application was superseded by a patent application. We have tested our second generation microdosimeter sensors with our bench-top and flight engineering instruments and compared our results favorably with those obtained at the University of Wollongong. We have completed testing new MIDN-III detectors, built with an SOI technology that reduces sensor noise over 10x. These sensors will allow accurate monitoring of protons of low energies, such as occur in a solar flare event. We completed an initial conceptual design of our instrument to fit within a NanoRacks configuration for deployment on the International Space Station through the auspices of the DoD Space Test Program. The NanoRacks configuration is modeled after the design of a cubesat. Our configuration would be 10 cm X 10 cm x 15 cm with the majority of the volume dedicated to a rechargeable battery power supply.

Stories

Articles in Peer-reviewed Journals
(https://techport.nasa.gov/file/8894)

Articles in Peer-reviewed Journals
(https://techport.nasa.gov/file/8884)

Articles in Peer-reviewed Journals
(https://techport.nasa.gov/file/25858)

Articles in Peer-reviewed Journals
(https://techport.nasa.gov/file/25001)

Articles in Peer-reviewed Journals
(https://techport.nasa.gov/file/26103)

Articles in Peer-reviewed Journals
(https://techport.nasa.gov/file/25260)

Articles in Peer-reviewed Journals
(https://techport.nasa.gov/file/8833)

Articles in Peer-reviewed Journals
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Articles in Peer-reviewed Journals
(https://techport.nasa.gov/file/8802)

Articles in Peer-reviewed Journals
(https://techport.nasa.gov/file/8820)

Awards
(https://techport.nasa.gov/file/8882)

Awards
(https://techport.nasa.gov/file/25786)

Awards
(https://techport.nasa.gov/file/25303)

Papers from Meeting Proceedings
(https://techport.nasa.gov/file/8806)

Project Website:

https://taskbook.nasaprs.com